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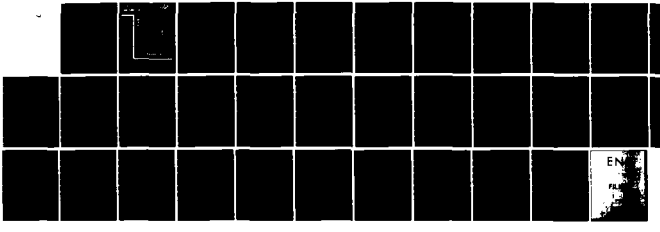

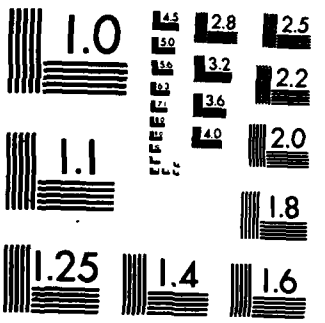

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DECISION-THEORETIC APPROACH TO PERSONNEL SELECTION: A REVIEW

By

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July 1984

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This paper provides a state-of-the-art review of personnel selection strategies based on application of Decision Theory and Utility Theory. Traditional personnel selection technologies are often too limited to be fully effective in a complex selection environment requiring more than one criterion. The decision-theoretic approach is a multidisciplinary extension of traditional technology. It is appropriate for complex decision problems requiring value judgments and cost considerations. Recent advances in decision-theoretic technology can provide for the development of an interactive, computer-assisted, decision support system that can be used in almost every selection situation.

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This document provides an extensive review of personnel selection strategies based on application of Decision and Utility theories.

SUMMARY

The objective of this report is to provide a review of the state-of-the-art of personnel selection strategies based on application of Decision Theory and Utility Theory.

The traditional selection of personnel for education or employment is based on the classical regression-analytic approach. This approach has an excellent history and is the preferred technology when the selection situation has a single criterion, such as quality. However, when two or more selection criteria must be satisfied simultaneously, the regression-analytic approach is too limited. Implementation of the Title VII of the Civil Rights Act of 1964 has created a new selection environment that is much more complex than the environment that existed during the development of the classical procedures. Personnel specialists must be concerned about minority representation and the risk of adverse impact as well as quality. The decision-theoretic approach to personnel selection is an augmentation or "extension" of traditional methods. It is appropriate for those selection problems too complex to be handled by classical psychometric means. This report is written for personnel specialists, researchers, and managers of human resources.

This report is based on an extensive review of the literature pertinent to the decision-theoretic approach to personnel selection. The review provides the historical development as well as the current state-of-the-art of this multidisciplinary approach.

Sixteen different utility models have been suggested for use in personnel selection since 1939. These models can be divided into two chronological groups: early utility models, and models implemented after the Civil Rights Act. Early utility models were primarily the products of economics, mathematics, and statistical decision theory. The second group of models resulted from specific studies on the issues of test bias and cultural fairness in selection. The decision-theoretic approach to personnel selection provides a mean for considering the subjective elements of the decision problem and a method for expressing alternative strategies in dollar terms.

Traditional personnel selection technologies are often too limited to be fully effective in a complex selection environment requiring two or more criteria. The decision-theoretic approach is a multidisciplinary extension of traditional personnel selection technology. It is appropriate for complex decision problems requiring value judgments and cost considerations. Recent advances in decision-theoretic technology can provide for the development of an interactive, computer-assisted, decision support system which can be used in almost every selection situation.

PREFACE

This study was completed under Task 771918, Selection and Classification Technologies, which is part of a larger effort in Force Acquisition and Distribution. It was subsumed under work unit number 77191819, "Officer Selection and Classification Measures." This work unit was established in response to Air Force Regulation 35-8.

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DECISION-THEORETIC APPROACH TO PERSONNEL SELECTION: A REVIEW

I. INTRODUCTION

Personnel selection is, first and foremost, a decisionmaking process. In employment selection, the decision to be made is to determine which of the available applicants will have the greatest likelihood of becoming successful employees. During the first 50 years of scientific personnel selection, decisions were relatively simple; applicants were rank-ordered based on potential quality. Most technological advancements were made by improving the standard transformations used to rank-order. Today's personnel specialist must operate within a framework constrained by requirements regarding not only quality, but adverse impact, minority representation, and costs. The purpose of this paper is to trace the historical development and to discuss the current state-of-the-art of an innovative technology appropriate for decisionmaking in a complex personnel selection environment.

The Decision-Theoretic Approach to personnel selection can be defined as:

> An extension and augmentation of traditional technology that is both more sophisticated and more realistic in that it incorporates political, social, legal, and monetary constraints into the decisionmaking process.

The development of the decision-theoretic approach and the way in which this approach differs from traditional selection are illustrated through the presentation of specific models. These models also illustrate the diversity of research and development (R&D) in this area. Of the 16 models presented in this review, the Brogden-Cronback-Gleser total utility model is considered the most important. This model seems to hold the most potential for use by practitioners who have actual selection problems in applied settings.

The decision-theoretic approach is based on the application of Decision Theory and Utility Theory. Using this approach, decisionmaking is the process of choosing between alternatives, and the choice of the most appropriate alternative is largely determined by the attractiveness, or value, of each alternative. This value is expressed as the utility of an action which leads to some outcome. Ultimately, utility is based on the assumption that the "perceived value" of the act chosen is higher than the perceived value of any other act considered at the time of choice (Becker & McClintock, 1967).

The actual manner in which the concept of utility is used is dependent on the specific utility model. Becker and McClintock (1967) classified utility models as either prescriptive or descriptive. Prescriptive or normative models prescribe how the decisionmaker should behave, by setting the ideal norm to be followed. These models "were designed to help people make 'better' decisions in the sense of aiding them to behave consistently with *some a priori set of requirements or rules* to which they want their choices to conform" (p. 239). Descriptive models were designed to reflect

how people actually behave. The prescriptive models are most appropriate for evaluating personnel selection strategies whereas the descriptive models are most appropriate for studies involving the behavioral aspects of individual or group decisionmakers.

Decision theory originated in economics with the economic theory of consumer's decisionmaking, also known as the Theory of Consumer's Choice. The school of philosopher-economists started by Jeremy Bentham in the early 1800's held that the goal of human action is to seek pleasure and avoid pain. The pleasure- or pain-giving properties of each action or object are called utilities, with pleasure producing a positive utility and pain, a negative utility. The goal of any human action, then, is to maximize positive utilities. This notion of utility maximization is the essence of the economic theory of choice (Edwards, 1954).

Personnel selection is analogous to the choice of product made by a consumer. That is, from among the different products (job applicants) available, a decision must be made by the consumer (employer) as to which product (applicant) will provide the greatest amount of satisfaction (success on the job). Usually, the actual utility (value) of the product (applicant) is not known until after the decision is made. Stated in more succinct terms, one of the major purposes of personnel selection is to make a prediction about the future job success of an applicant. The actual performance on the job by an applicant is never known at the time of selection. Instead, there is a probability of success associated with each selection decision.

By 1950, the theory of consumer's choice had become quite elaborate and mathematical, and its potential for application on psychological problems was well established (Katona, 1946, 1947; Lewisohn, 1938; Weisskopf, 1949). Despite pleas in both the psychological and economic literature, the theory was not used in applied settings by psychologists (Edwards, 1954).

II. EARLY UTILITY MODELS

The first, and probably best known, application of utility to personnel selection was the model suggested by Taylor and Russell (1939). Taylor and Russell demonstrated that even a slightly valid selection instrument could increase the proportion of successful employees selected (increase in success ratio) when compared to random selection. The success ratio serves as "an operational measure of the value or utility of a selection device" (Cascio, 1982, p. 133).

When the outcome of a decision is unknown, a condition of either risk or uncertainty exists. Although these two probability-based concepts are quite similar, economists and statisticians distinguish between risk and uncertainty in the following manner. Propositions about the future based on generally accepted probabilities that the proposition is true are considered to be cases of risk. Propositions about the future to which no generally accepted probabilities can be attached are considered to be cases of uncertainty. Examples of a risky decision would be those based on the toss of a coin or the roll of a die, whereas the likelihood that gold will be

$500 an ounce on the world market 1 year from today would be an example of a case involving uncertainty. Thus, decisions under conditions of risk involve objective probabilities whereas decisions under conditions of uncertainty involve subjective probabilities.

The literature on risky decisionmaking prior to 1944 was limited to examples of gambling outcomes and some literary discussion in economics (Edwards, 1954). The modern period in the study of risky decisionmaking began with the publication of Theory of Games and Economic Behavior by von Neumann and Morgenstern (1947). Their book served to present ways to analyze the problems of strategy. The theory of games offered no practical help in developing strategies, but it did offer rules about how to choose among them. Their approach was oriented toward risky choices and provided notions on the measurement of utility.

The statistical approach to decisionmaking had been introduced by Neyman and Pearson (1933). Later, Abraham Wald (1950) combined statistics with the application of the game theory. He reformulated the problem of statistical decisionmaking as one of playing a game against nature. Wald provided a treatment of the design of experimentation as part of the general decision problem and extended the statistical theory of testing hypotheses into a general statistical decision theory. The statistical decision theory includes techniques for application to those problems involving uncertainty, as well as risk.

The von Neumann-Morgenstern-Wald Model, which combines the theory of games with statistical decision theory, is based on the principle of the rational-economic man. This model requires a four-step process when used in the personnel selection context. First, given the range of possible test scores, the conditional probability of success at each outcome is stated quantitatively. Second, the desirability, or utility, of each outcome is also stated quantitatively. Next, the probability of each outcome is multiplied by the utility of each outcome and the products are summed to provide an expected utility. Finally, the alternative which has the highest expected utility becomes the preferred choice. Girshick (1954) summarized the characteristics of this model by stating that it "insists that cost consideration and consequences of decisions be taken into account in every statistical investigation" and that it "bridges the gap existing in classical statistics between testing hypotheses and estimation" (p. 464).

The next major application of the utility concept to personnel selection came toward the end of World War II. Brogden (1946) demonstrated that there were limitations to using the correlation coefficient to show the efficiency of prediction. Since a test or battery of tests is employed as a means of selecting the individuals who will perform most efficiently on the job, some measure of efficiency on the job must be employed as a criterion. Therefore, if maximum utility is defined as the level of productivity gain that would result from hiring on the basis of a perfectly valid test instrument, then the validity coefficient between the test and performance on the job is simply a measure of the proportion of the maximum attainable utility.

Three years later, Brogden (1949) addressed the concept of cost-utility by pointing out that the use of valid tests can save money. The actual amount saved depends on (a) "the effectiveness of the selection instruments in predicting efficiency on the job" and (b) "the percentage of applicants who must be considered" (p. 171). In addition to validity and selection ratio he added a third factor, the cost of testing. He then showed the relationships of these factors to the savings resulting from testing. He used the principles of linear regression to show how the economic utility of a selection device can be affected by the selection ratio and the standard deviation of job performance expressed in dollar terms. While straightforward and simple to understand, "Brogden's derivations are a landmark in the development of selection utility models" (Hunter & Schmidt, 1982, p. 236).

The concept of utility expressed as costs was expanded the following year to include application toward criterion construction. Brogden and Taylor (1950) introduced a cost accounting approach to the problem of determining an appropriate and meaningful criterion. Their approach was to develop a dollar criterion which would be of value in "converting the criterion variables to units most meaningful and satisfactory to an industrial sponsor of validation research" (p. 148). They indicated that by combining training costs, turnover, and on-the-job productivity into units expressed in dollar amounts, it would be possible to develop "a single index showing the total picture of the potential value of an applicant" (p. 148). This index was referred to as the standard deviation of the dollar criterion, or SD_y. Thus, the utility of a selection procedure could be determined by criterion measures expressed in dollar terms.

The use of utility in making selection decisions also began to appear in the sociology literature. Goodman (1953) suggested a procedure for determining the accuracy and efficiency of several predictive instruments by using them simultaneously during the decision process.

At about the same time, a group of sociologists at the University of Chicago (Duncan, Ohlin, Reiss, & Stanton, 1953) developed a variety of selection decision rules that could be stated within a cost-utility framework. They investigated the formal properties of a class of decision rules used to determine cut scores on a test. By graphing the function of the "utility" of a given score on a prediction instrument and the associated "cost" at that score, it would be possible to develop a "cost-utility curve." The cost-utility curve would then serve as the basis for the formulation of several alternative decision rules. The ultimate goal of their approach was the construction of formal selection devices.

The first complete analysis of application of decision theory and utility theory to personnel selection problems was the monumental book, Psychological Tests and Personnel Decision, by Cronbach and Gleser (1957). They expanded Brogden's generalizations that decisions about the interpretation of the validity coefficient can be evaluated directly on a utility scale. Cronbach and Gleser demonstrated mathematically that the "value of a test can be stated only in terms of the specific type of

decision problem, the strategy employed, the evaluation attached to the outcome, and the cost of testing" (p. 32).

Cronbach and Gleser's formulas were identical to Brogden's except that they formally incorporated the cost of testing into the equations. Also, Brogden approached the selection decision with an emphasis on the mean gain in utility per selectee, whereas Cronbach and Gleser derived their equations in terms of the mean gain in utility per applicant. Thus, by multiplying the mean gain in utility per applicant by the number of applicants, it would be possible to determine the total or overall gain in utility from use of a particular selection device. When first published, Psychological Tests and Personnel Decisions was considered to be "an important book which may lead to the development of a new and quite different theory of tests" and could be "viewed as a logical extension of the long history of criticism of a test theory which is reliability-based, and which handled validity so awkwardly" (von Haller Gilmer, 1960 p. 327).

The Brogden-Cronbach-Gleser Utility Model suggested the use of decision theory as a way of replacing, or at least augmenting, traditional test theory. It defined personnel selection as a decisionmaking process and considered costs as an important factor in determining the value of a prediction device. But, because an accurate estimation of costs was one of the most difficult elements of the equations to obtain, the use of this model was limited. Even the authors believed the estimation of costs to be the "Achilles' Heel" of utility in personnel decisionmaking.

In 1965, Cronbach and Gleser reissued their book and included a "Guide to Relevant Literature" in the new edition. But as Guion (1967) pointed out, "There is little sign that either edition has had much impact on actual selection procedures, whether because of the complexity of the concepts or because of the near-impossibility of translating the major designs into employment office activity" (p. 205).

Shortly after the introduction of the first Cronbach and Gleser book, Kao and Rowan (1958) presented a mathematical model for determining a minimum cost strategy for personnel recruiting and selection in certain situations. The Kao-Rowan Model addressed the problem of employing adequate numbers of suitably trained technical personnel. The Brogden-Cronbach-Gleser Utility Model is concerned with maximizing average productivity based on the number of applicants to be hired. The Kao-Rowan Model, however, considers the problem "of filling a personnel quota where the quota is not in terms of people to be hired but rather in terms of people productively on the job, that is, selected, trained, and shown to be satisfactory in the position to be considered" (p. 193). In other words, Kao and Rowan developed a model for determining the strategy which would "yield a minimum cost subject to a given probability that at least a fixed number of good employees will be hired" (p. 194). With only slight modification, this model could be adapted for use in other types of selection environments.

Expected utility maximization, representative of the models described above, is characterized by the combination of subjective value or utility

and objective probability. By the mid-1950s, "it was already clear that expected utility maximization models were unsatisfactory" at measuring the utility of nonmonetary attributes and that "the crucial necessary change was to replace objective with subjective probability in such models" (Edwards, 1961, p. 478). But few personnel specialists understood subjective, or Bayesian, probability.

To facilitate this change from objective to subjective probability, Edwards (1961) modified his original "Theory of Decision-Making" (Edwards, 1954) by incorporating the concepts proposed by Savage (1954). He named his new model the Subjectively Expected Utility Maximization Model (SEU). The SEU model asserts that people maximize the product of subjective utility and subjective probability.

The feature that distinguishes the SEU Model from the others is the concept of subjective probability, which Edwards described by stating that, "Individuals can freely choose any subjective probabilities they like, prior to the first occurrence of an event; thereafter the change in subjective probability as a result of experience is governed by Bayes's Theorem" (p. 478). The SEU Model is primarily oriented toward individual decisionmaking. But, as Cronbach and Gleser (1957) pointed out, "Although many important personnel problems may require a decision theory based on the individual's value system, test theory, as it now stands, is relevant chiefly to institutional decisions" (p. 9). Therefore, even though the SEU model could be adapted for use in the personnel selection environment, it is more appropriately limited to an area of specialization in psychology known as behavioral decisionmaking.

Other researchers (Coombs & Komorita, 1958; Galanter, 1962; Irwin & Smith, 1957) introduced methods for measuring utility and subjective probability and attempted to define the significance of each concept. But, the next "major" advance in the development of decision theory came with the publication of Applied Statistical Decision Theory by Raiffa and Schlaifer (1961). They built upon the earlier works of Girshick (1954), Neyman and Pearson (1933), Savage (1954), von Neumann and Morgenstern (1947), and Wald (1950) in an effort to apply mathematics and statistics to business problems of decision under conditions of uncertainty. They developed new techniques which applied utility theory and the use of subjective probability to the analysis of business problems.

The focus of the Raiffa-Schlaifer Model is to use Bayesian principles in order to provide a "formal mechanism" for making the intuitive preferences of the decisionmaker more objective. One of the most important techniques introduced by the Raiffa-Schlaifer Model is use of the "decision tree" as a means of representation of the information pertinent to the problem at hand. The decision tree is an analytical tool for clarifying the different elements involved in a problem. The greatest value of decision trees is in "laying out" in a more systematic manner what the decisionmaker knows. Magee (1964) summed up the requirements for making a decision tree as follows:

1. Identify the points of decision and alternatives available at each point.

2. Identify the points of uncertainty and the type or range of alternative outcomes at each point.

3. Estimate the values needed to make the analysis, especially the probabilities of different events or results of action and the costs and gains of various events and actions.

4. Analyze the alternative values to choose a course.

The quantitative techniques introduced by Raiffa and Schlaifer were combined with the cost concepts of the Brogden-Cronbach-Gleser Model by Mahoney and England (1965). They suggested a Probabilistic Model of selection and demonstrated its advantages by comparison with two traditional models. The first traditional approach, selection ratio (Stone & Kendall, 1956), establishes a cutting score and decision rule for selection based on a fixed supply of candidates and a fixed selection ratio. In the second traditional approach, maximum differentiation (Meehl & Rosen, 1955), the focus is on "hit rate" or accuracy of classification. The authors point out that the limitations of traditional approaches are (a) failure to consider the marginal probabilities of success and failure and (b) failure to consider the cost consequences of their application.

Through the use of equations derived from statistical decision theory, and with the aid of simple decision trees, the authors assessed the probability measures of the actual employee selection process. In addition to considering empirically derived probabilities as essential elements of the Probabilistic Model, Mahoney and England considered three costs in the application of a selection decision rule: (a) the total cost of obtaining a successful candidate, (b) the opportunity cost of rejecting a successful candidate, and (c) the cost of accepting a failure candidate.

In the same year, Naylor and Shine (1965) suggested an approach which was in contrast to the Taylor-Russell utility model. While Taylor and Russell (1939) suggested that utility is affected by selection ratio and base rate, Naylor and Shine assumed a linear relationship between validity and utility at all selection ratios. Additionally, the Naylor-Shine Model differed from the Taylor-Russell Model in that the former "does not require that employees be dichotomized into satisfactory and unsatisfactory groups by specifying an arbitrary cutoff on the criterion (job performance) dimension that represents minimally acceptable performance" (Cascio, 1982, p. 132). The Naylor-Shine "index of utility," however, is not appropriate when the differences in criterion performance are expressed in dollar terms since the use of a dollar criterion may result in curvilinear relationships due to the nature of fixed and variable costs.

The recurrent theme appearing in the literature was the limitations of traditional methods for resolving new selection decision problems and the need for a suitable replacement. Dunnette (1979) suggested a modified and more complex prediction model to replace the classical prediction model that

he felt to be grossly oversimplified. He also believed that there were certain trends emerging that would lead to a new kind of selection. The situation Dunnette described was ideally suited for the more sophisticated techniques found with the decision-theoretic approach, but most of the psychological applications of utility and decision theory during that period were in the area of behavioral decisionmaking (Becker, 1962; Becker, DeGroot, & Marschak, 1963, 1964; Buchwald, 1965; DeGroot, 1963; Edwards, 1962; Edwards, Lindman, & Savage, 1963; Edwards & Slovic, 1965; Grant, 1962; Rimm, 1963).

III. MODELS IN RESPONSE TO THE CIVIL RIGHTS ACT OF 1964

With the Congressional enactment of the Civil Rights Act of 1964, there appeared to be the right combination of events necessary to stimulate an intense research interest in the application of the decision-theoretic approach to personnel selection. However, just the opposite began to occur.

The Civil Rights Act of 1964 forced researchers and practitioners in personnel psychology to evaluate the personnel selection models in use. Not only must these procedures provide a means for predicting which job applicants are most likely to be successful, they must be "culture-fair" in the process. But instead of implementing new selection models that were more sophisticated and more realistic, the immediate reaction of most personnel psychologists was to "defend" the traditional models.

Issues of the Annual Review of Psychology covering the period from 1964 through 1971 (Biesheuvel, 1965; Bray & Moses, 1972; Owens & Jewell, 1969) show little evidence of decision-theoretic research in personnel selection. Only two studies (Darlington & Stauffer, 1966; Guttman & Raju, 1965) addressed this approach to selection. During this period, much of the literature on decision theory (Eilon, 1968; Marks, 1971; Shell & Stelzer, 1971), utility theory (Fishburn, 1968; Hammond, 1967; Swalm, 1966), and the Bayesian approach to subjective probability (Gettys & Willke, 1969; Roberts, 1965) was written with an orientation toward management science problems, which occasionally touched on personnel issues. For example, Smith and Greenlaw (1967) developed a computer simulation of the decision process used by a psychologist. The Smith-Greenlaw Model was an attempt to define explicitly the subjective tradeoffs required when a decisionmaker compares alternatives.

The psychological literature in this area continued to be sparse throughout the first half of the 1970's. Ash and Kroeker (1975) reported that "there has been only slight activity in the general area of mathematical modeling of decision strategies in personnel selection" (p. 495). With few exceptions (Gross, 1973; Sands, 1973; Schmidt & Hoffman, 1973), little research was reported on the utility of selection devices.

Management scientists and statisticians were making advances in research on the decision-theoretic approach. In addition to applied decision theory (Ives, 1973) and utility (Berhold, 1973), progress was made with multiattribute utility analysis (Keeney, 1972, 1975) and computer-based decision aids (Keen, 1975; Novick, 1973).

In 1976 the decision-theoretic approach to personnel selection experienced a revitalization. Petersen and Novick (1976) addressed the major problem of how to eliminate cultural or racial unfairness from the use of tests in the personnel selection process and discussed the major models that had appeared. Their purpose was to point out the inadequacies of some of these models and to show that a more complex analysis would be required to resolve the problem. Petersen and Novick evaluated nine models which they referred to collectively as the "models of test bias." The evaluation included the Regression (Cleary, 1968), Equal Risk (Einhorn & Bass, 1971), and Culture-Modified Criterion (Darlington, 1971) models of fairness in selection, and a subset of models which Sawyer, Cole, and Cole (1976) referred to as the "group parity models." These were the Constant Ratio (Thorndike, 1971), Conditional Probability (Cole, 1973), and Equal Probability (Linn, 1973) models. In order to complete the analysis, Petersen and Novick defined three "converse" models, one for each of the three group parity models.

The authors provided explanations as to why these models were not completely satisfactory. For example, regarding the group parity models and their converse models, they stated, "Each model deals with only one aspect of the culture-fair selection issue" (p. 21). They were able to show that these models "sometimes can produce most undesirable results and could, in fact, be used to justify discrimination against some minority groups" (p. 24). In their appraisal of the test bias models, Petersen and Novick considered these models to be internally contradictory and contraindicated.

Petersen and Novick next addressed the concept of maximizing expected utility. According to the authors, the group parity models were not acceptable since they did not use subjective probabilities. However, the Regression Model and the Equal Risk Model they considered appropriate to the decision-theoretic approach to personnel, even though the models were not specifically addressed as such when formulated.

The last of the nine models evaluated by the authors was the Culture-Modified Criterion Model. Regarding this model, Petersen and Novick stated that it "is the only model surveyed that addresses itself to the utility question." However, they went on to say that the formulation of this model "is still not entirely consistent with the decision-theoretic approach (i.e., it does not incorporate a formal utility function), and hence may not be acceptable" (p. 26).

Petersen and Novick suggested that a more appropriate model was the Threshold Utility Model initially proposed by Gross and Su (1975) and subsequently analyzed by Petersen (1976). Basically the Threshold Utility Model will select those applicants with the highest expected utility. The advantage of this model is that it requires "an explicit public statement of utilities for each subpopulation" (p. 28). Darlington (1976) believed that there was a definite need to expand the concept of culture-fairness beyond the traditional psychometric terms to include the social and political aspects of personnel selection. He also believed that the group parity models would "lead to discussions involving two totally unrelated types of arguments (psychometric and political), in which half the participants

cannot understand half the arguments, and in which there is no room for compromise. It is hard to imagine a better formula for destroying relations between the testing profession and the public" (p. 47).

Petersen and Novick urged Darlington to restate his model such that it might be evaluated more easily. Darlington (1976) responded by providing a defense for his approach, while at the same time presenting two new techniques for use in personnel selection. One technique could be used to determine how many minority applicants should be admitted to an institution. This technique was a simple graphical method which could be used by nontechnical personnel. The second technique was a large-scale computer method which could be used by an institution to increase personnel diversity on many variables simultaneously. Darlington specified that these techniques were still based on the same general view he had expressed earlier: that human judgment should be used to resolve personnel selection problems regarding culture. Since the emphasis is on the human judgment, or rational, approach, he proposed a Rational Model which would provide substantial advantages over his previous "corrected-criterion" method. He defined the Rational Model by stating that "the rational approach to the culture-fairness problem holds that in personnel selection, members of certain minority cultural groups may reasonably be given preference over other applicants, and that the amount of preference should be determined at a policy level, considering social, historical, and political factors which cannot be quantified." Further, "it should not be determined by a mechanical formula" (p. 43).

In determining that membership in a cultural group should be made some part of the total criterion, Darlington stated that the specification of "how much weight to give to this part of the criterion is a question which must be answered by policymakers rather than by psychometric technicians" (p. 43). He also mentions that his earlier papers can be put into decision-theoretic terms by merely interpreting the word "criterion" to mean "utility."

A similar theme was used by Cronbach (1976), who pointed out that the decision-theoretic approach could be used to state propositions in more precise terms. He cautioned that further work in the area "would be needed to produce a formal framework for mathematical, philosophical, legal, and political discourse" (p. 31). In emphasizing the significance of using a decision-theoretic approach, Cronbach stated, "Make no mistake. The issues will not be settled by mathematical specialists. Utility theory cannot be expected to crank out a just answer to a question of resource allocation" (p. 31).

Cronbach presented a comparison of methods by first mentioning that each psychometric concept of "fair selection" can be embodied in an index. When the value of the index is equal for all subgroups, selection is fair. He then established a series of 10 indices representing the three major points of view: employer, applicant, and group. The first four indices, or ratios, can be used to maximize the employer's expected utility (EEU), such as "hiring from the top." The next four can be used to maximize the applicant's expected utility (AEU), such as is found with a "quota" system,

and the last two indices are focused on group utilities and will be important when "the applicant might in principle be concerned with the net payoff for his group" (p. 39). The appropriate rationale, as defined by the particular indices used, will result in a viable personnel selection system.

To represent the preferred payoff matrix, Cronbach presented a "heuristic simplification" which he referred to as an "hs" matrix. This matrix incorporates the utility of being hired, "h," and the utility of being successful, "s," once hired. His Equal Marginal Risk (EMR) Model is defined as the ratio which indicated the marginal increase (decrease) in the probability that the random applicant would be hired and successful to the marginal increase in the selection ratio. The emphasis was on marginal values and he was primarily interested in the specified marginal risk associated with an applicant. Therefore, he called his approach an equal marginal risk strategy to distinguish it from equal risk, equal conditional risk, or equal overall risk as used in earlier models.

Linn (1976) agreed with Darlington (1976) and Cronbach (1976) when he stated that part of the difficulty with test bias models "is that they attempt to provide a purely technical resolution to an issue that involves value judgments" (p. 54). Sawyer, Cole, & Cole (1976), in comparing the regression-analytic to the decision-theoretic approach, stated that there is "a growing recognition that the issues of fair selection are not primarily technical ones but are matters of value judgments about the proper definition of fairness" (p. 59).

Four papers (Cronbach, 1976; Darlington, 1976; Linn, 1976; Sawyer, Cole, & Cole, 1976) were provided in response to the Petersen and Novick (1976) article. The papers were provided specifically in response to an invitation by the editor of the Journal of Educational Measurement to provide updated statements on the views of leading personnel selection researchers on the fair use of tests in education and employment selection. An invitation was also made to Petersen and Novick to comment on the four papers and to indicate if there was any further development in their own thinking. Novick and Petersen (1976) provided a rejoinder in which they commented, "There has been no change in our basic position, only a strenthening of it. Where we initially (as early as 1972) spoke with some hesitancy, we now speak with greater conviction." (p. 77)

Although complex and sophisticated, Novick and Petersen have provided for the appropriate transfer of technology. In the discussion of the new model, they said, "We have the necessary technology available to make the Cumulative Normal Ogive Utility Model available to all, literally all, potential users" (p. 85).

Almost 40 years of development on the decision-theoretic approach has resulted in many suggestions and proposals. The important consideration of this development is that it has been a multidisciplinary effort at improving personnel selection. Table 1 provides a summary of the major decision-theoretic models developed up through the late 1970s.

Table 1. Utility Models Used in Personnel Selection

Model	Key Features	Sources
Early Models		
Taylor-Russell	Introduced the concepts of base rate and selection ratio to be used in conjunction with test validity. Utility measures as increased in success ratio.	Taylor & Russell (1939)
von Neumann-Morgenstern-Wald	Combines Theory of Games with Statistical Decision Theory. Based on principle of rational-economic man. Uses objective probability,subjective utility.	Neyman & Pearson (1933) von Neumann & Morgenstern (1947) Wald (1950) Girshick (1954)
Brogden-Cronbach-Gleser	Uses Decision Theory to replace or augment traditional Test Theory, includes concept of cost.	Brogden (1946, 1949) Brogden & Taylor (1950) Cronbach & Gleser (1957)
Kao-Rowan	Mathematical Programming used to minimize cost of hiring technical personnel.	Kao & Rowan (1958)
Subjectively Expected Utility (SEU) Maximization	Combines subjective probability and subjective utility. Most appropriate for behavioral decisionmaking.	Savage (1954) Edwards (1954, 1961)
Raiffa-Schlaifer	Applies Utility Theory and Bayesian statistics to business problems of decision under conditions of uncertainty.	Raiffa & Schlaifer (1961)
Models Implemented after Civil Rights Act		
Probabilistic	Assesses probability measures in employee selection and considers various types of costs in making decision rules.	Mahoney & England (1965)
Naylor-Shine	Assumes a linear relationship between validity and utility which holds at all selection ratios.	Naylor & Shine (1965)

(continued)

Table 1 (Continued)

Model	Key Features	Sources
Smith-Greenlaw	Uses computer to simulate the decision process used by a psychologist in selecting personnel.	Smith & Greenlaw (1967)
Regression	Special case of general decision-theoretic formulation.	Cleary (1968)
Equal Risk	Special case of general decision-theoretic formulation.	Einhorn & Bass (1971)
Culture-Modified Criterion	Incorporates the concept of culture into selection decisions. Does not use formal utility functions.	Darlington (1971)
Threshold Utility	Selects applicants with highest expected utility. Requires explicit public statement of utilities for each subpopulation.	Gross & Su (1975) Petersen (1976)
Rational	Imporance of culture in the criterion should be determined by policy-makers.	Darlington (1976)
Equal Marginal Risk (EMR)	Uses 10 indices to measure employers' expected utility (EEU), appliants' expected utility (AEU), and group utility.	Cronbach (1976)
Cumulative Normal Ogive Utility	Complex and sophisticated equations incorporated into computer assisted data analysis (CADA).	Novick & Petersen (1976) Novick & Lindley (1978)

IV. REFINEMENT OF THE DOLLAR CRITERION

Taylor and Russell (1939) demonstrated that the utility (expressed as an increase in successful workers) of a selection instrument could be determined by knowing three values: (a) the validity of the selection instrument, (b) the base rate (i.e., the percentage of applicants who would be successful without the test), and (c) the selection ratio. They provided a set of tables which allowed a decisionmaker to determine the utility of his or her particular selection situation. Although the Taylor-Russell tables were a major advance in personnel selection, there are two significant disadvantages to the use of this approach. First, the approach requires a dichotomous criterion which results in the loss of information about the applicants. Second, the decision as to where to create the dichotomy is arbitrary. Thus, "the Taylor-Russell approach appears to give different answers to how useful a test is, depending on where the arbitrary dichotomy is drawn" (Hunter & Schmidt, 1982, p. 235).

Brogden (1949) expanded on the work of Taylor and Russell to demonstrate how the selection ratio and the standard deviation of job performance in dollars (SD_y) could affect the economic utility of a selection instrument. While Taylor and Russell demonstrated how the interrelationship of validity, selection ratio, and base rate could be used to determine the utility of the selection instrument, Brogden used validity, selection ratio, and testing cost to show utility as the savings resulting from testing. He showed that "the validity coefficient can be interpreted as the ratio of the saving actually achieved by the use of selection instruments to the saving which would be achieved by selection on the criterion itself" (p. 178). Allowing for the cost of testing, he suggested that utility could be expressed as the expected saving per individual selected by using the following formula:

$$M_{(y-c)} = r\sigma_y \, z/p - c/p$$

where

$M_{(y-c)}$ = mean gain per selectee

r = validity coefficient of the selection instrument

σ_y = standard deviation of job performance measured in dollar value

z/p = mean test score of the selected group (in standard score form)

c = cost of testing a single individual

p = the selection ratio

The only element of this formula that was difficult to obtain was σ_y, but Brogden pointed out, "For purposes of this presentation the exact value of σ_y was considered unimportant and assumed to be unity" (p. 179).

However, σ_y was important. Brogden and Taylor (1950) proposed a "rationale for the construction of an overall measure of worker effectiveness" (p. 133). They stated that "the criterion should measure the contribution of the individual to the overall efficiency of the organization" (p. 139) and referred to σ_y as the "dollar criterion."

Cronbach and Gleser (1957) expanded on Brogden's work and stated that "the net gain in utility per man tested from selection for a fixed treatment is linearly related to the validity of the test" (p. 37). They expressed utility in terms of mean gain per applicant:

$$\Delta U/\text{applicant} = \sigma_e r_{ye} \xi(y') - C$$

where

ΔU/applicant = mean gain per applicant

σ_e = the standard deviation of this payoff

r_{ye} = the correlation of the test with the evaluated criterion in the a priori population

$\xi(y')$ = the ordinate of the normal curve at the cutting score

Cy = the average cost of testing one person

Their formulation for utility is identical to the one proposed by Brogden (1949). As Cronbach and Gleser note, "Most of the conclusions implicit in equation [2] were originally pointed out by Brogden" (p. 38).

At first, it is difficult to see how the two equations are equal, especially since Brogden's equation expresses utility in terms of the mean gain per selectee whereas the one suggested by Cronbach and Gleser expresses utility in terms of mean gain per applicant. But, Hunter and Schmidt (1982) show how the two equations are identical. Ignoring the cost of testing for the moment, it is assumed that (a) the relation between the test and job performance is linear and (b) the test scores are normally distributed, then Brogden's equation can be written:

$$\Delta U/\text{selectee} = r_{xy} SD_y \sigma/p$$

where

U/selectee = mean marginal utility per selectee

r_{xy} = validity coefficient of the test

SD_y = standard deviation of job performance in dollars

p = the selection ratio

σ = the ordinate in N (0,1) at the point of cut corresponding to p

Since the total utility is the mean marginal utility per selectee times the number of people selected, N_S, the total productivity gain is:

$$\Delta U = N_S r_{xy} SD_y \sigma / p$$

The initial Cronbach and Gleser formula for mean marginal utility per applicant is:

$$U/\text{applicant} = r_{xy} SD_y$$

And the total or overall gain in utility is:

$$\Delta U = N r_{xy} SD_y \sigma$$

Since p is the selection ratio, then $p = N_s/N$. This will reduce Brogden's equation for total utility to the following:

$$\Delta U = N r_{xy} SD_y \sigma$$

This is identical to the Cronbach and Gleser equation for total utility.

One additional consideration regards cost. As was pointed out by Hunter and Schmidt (1982), the cost of testing is a one-time cost, but the "utility gains continue to accumulate over as many years as the person hired stays with the organization" (p. 240). They have expanded the Brogden-Cronbach-Gleser (BCG) total utility formula to include consideration for employee tenure. The Hunter-Schmidt (HS) formula for total utility (Hunter & Hunter, 1982 p. 47) computes the gain in productivity for 1 year of hiring due to selection as follows:

$$\Delta U = N\ T\ r_{xy} \sigma_y \bar{x}$$

where

ΔU = total utility

N = number of persons to be hired during the year

T = the average tenure (in years) of those hired

r_{xy} = validity of selection instrument (corrected for error of measurement in job performance and for restriction in range)

σ_y = standard deviation of performance in dollar terms

x = the average predictor score (in standard score form)

As with the BCG utility formula, the most difficult term to obtain was σ_y.

However, a major breakthrough in the Hunter and Schmidt analysis has been the discovery of an empirical relation between σ_y and annual wage, which indicates that σ_y is usually at least 40% of the annual wage. "This empirical baseline has subsequently been explained in terms of the relationship between pay and the value of output which is typically about two to one (because of overhead). Thus a standard deviation of 40% of wagesderives from a standard deviation of output of 20%" (Hunter & Hunter, 1982 p. 47). It must be pointed out σ_y is not the standard deviation of wages, but the standard deviation of work output (Hunter, 1981). In a recent study, Schmidt and Hunter (1983) report findings that "support the use of 40% of salary as an estimate of the standard deviation of productivity in dollars" (p. 407).

V. RECENT DEVELOPMENTS

The decision-theoretic approach has been referred to in the past as "a new and quite different theory of test" (von Haller Gilmer, 1960, p. 327) and a way of "replacing or augmenting traditional test theory" (Guion, 1967, p. 191). This approach is "both more sophisticated and more realistic than traditional validation models" (Guion, 1967, p. 206). It has been viewed as an extension of the traditional methods and is appropriate for those selection problems too complex to be handled by classical psychometric means. The recent literature is consistent with this view. Brabb and Livingston (1976) point out that the decision-theoretic paradigm is not in conflict with the classical paradigm, but is a natural and logical extension of it. Despite repeated calls for incorporation of this approach, it has generally not been accepted. As Dunnette and Borman (1979) point out, "Personnel selection has seldom incorporated formal utility concepts. Despite the considerable advances in utility theory, the question of dollar savings which might be realized by instituting a selection program continues to receive almost no attention" (p. 538).

Although there has been a lack of operational acceptance, there has been an increasing interest in utility theory among personnel researchers since 1976. Novick and Ellis (1977) elaborated on the advantages of the decision-theoretic approach over the group parity models. Novick and Lindley (1978) discussed the various forms a utility function might take in selected applications and how they could be used. And Novick (1978) discussed how the normal ogive, when used as a utility function, would be a "clear improvement over threshold utility" (p. 3).

Hunter, Schmidt, & Rauschenberger (1977) discussed the implications of selection utility with regard to the fairness of psychological tests. They stated there has been "increasing recognition by selection psychologists that choice of a fairness model cannot satisfactorily be made solely on statistical bases; questions of social policy and social values necessarily enter into the choice" (p. 248). Schmidt, Hunter, McKenzie, and Muldrow (1979) used decision-theoretic equations to estimate the impact of a valid aptitude test on the productivity of computer programmers. They believed that the "results support the conclusion that hundreds of millions of dollars in increased productivity could be realized" (p. 609). They also developed a procedure for estimating the standard deviation of job

performance in dollar terms. Their global estimation procedure was a milestone in the development of the decision-theoretic approach to personnel selection since it provided a means for determining the dollar criterion. This determination had eluded personnel researchers for a quarter of a century.

Cascio and Silbey (1979) also used the decision-theoretic approach to evaluate selection procedures based on assessment centers. They agreed with Schmidt et al. (1979) and concluded that valid selection procedures could have a great impact on work-force productivity. In a similar study using archival data from a large insurance company, Bobko, Karren, and Parkington (1983) used the procedure for estimating the standard deviation of job performance developed by Schmidt et al. (1979). They demonstrated that "this evaluation procedure is quite accurate in reproducing actual standard deviations" (p. 170). They concluded that "data on an objective measure of performance indicates optimism for the estimation of SD_y in utility analysis" (p. 176).

In a discussion on the future of criterion-related validity, Schmidt and Hunter (1980) suggested that "application of decision theory equations in the future will do much to clarify the critical role that selection plays in determining organization success" (p. 56). They further suggested that increased use of decision-theoretic dollar utility analysis "will convince many who are presently skeptical" (p. 56). Schmidt, Hunter, and Pearlman (1982) have made an "adaptation of the linear regression-based decision-theoretic equations used to estimate the dollar impact of valid selection procedures" (p. 333). Pointing out that "organizational success depends not only on the quality of the people selected into the organization, but also how they are managed after selection" (p. 334), the authors show how the decision-theoretic equations can be modified to estimate the dollar value of an organizational intervention, such as training. On a much larger scale, Hunter and Schmidt (1982) applied the decision-theoretic equations to a classification model which can estimate the impact of job assessment strategies on national productivity. Boudreau (1983a) has incorporated the economic concepts of variable costs, taxes, and discounting into utility formulas. And Boudreau (1983b) has incorporated dollar-refined utility estimates into economic analysis of the flow of employees through the work force.

Ben-Shakhar and Beller (1983) applied the decision-theoretic approach to a quota-free selection problem, specifically the selection of college students. They developed an "index of usefulness" of the predictor which they defined in terms of "its contribution to the expected utility of the possible outcomes of the decision problem" (p. 137). They concluded their study by stating, "We see the main contribution of the present study as demonstrating the application of a decision-theoretic framework to personnel selection" (p. 145).

The concept of Equal Marginal Risk proposed by Cronbach (1976) has been incorporated into a computer simulation model that can be used to analyze tradeoffs among different selection strategies (Cronbach, Yalow, & Schaeffer, 1980; Cronbach, 1980). Schaeffer and Cronbach (1980) and

Cronbach and Schaeffer (1981) demonstrated that the state of the art had progressed from the conceptual stage to the applications stage. Cronbach, Yalow, and Schaeffer developed their model for educational selection but stated that it could also be applied to an organizational setting. Their model was modified by Kroeck, Barrett, and Alexander (1983) to provide a computer simulation of imposed quotas in industrial selection. They reported that "generally, our results regarding selection without replacement from a fixed applicant pool conform to those reported by Cronbach et al. (1980)" (p. 127).

In 1979, Dunnette and Borman wrote that the "main reasons for failure to employ utility analysis seem to be ignorance about how to apply the somewhat complicated equations and difficulty in costing some of the elements of the equations" (p. 493). Literature reported in the past 5 years indicates that these difficulties are being overcome and the decision-theoretic approach to personnel selection is finally gaining acceptance. Table 2 summarizes some of the recent applications of this approach.

Table 2. Recent Applications of the Decision-Theoretic Approach

Application	Source
Replacement of group parity models	Novick & Ellis (1977)
Productivity of computer programmers	Schmidt, Hunter, McKenzie, & Muldrow (1979)
Selection based on assessment centers	Cascio & Silbey (1979)
Computer simulation of educational selection	Cronbach, Yalow, & Schaeffer (1980)
Impact of job assessment strategies on national productivity (classification)	Hunter & Schmidt (1982)
Estimates of organizational intervention (training, etc.)	Schmidt, Hunter, & Pearlman (1982)
Incorporating the flow of employees into and out of the work force as a variable affecting personnel program utility	Boudreau (1983)
Quota-free educational selection	Ben-Shakhar & Beller (1983)
Productivity of insurance counselors	Bobko, Karren, & Parkington (1983)
Computer simulation of industrial selection	Kroeck, Barrett, & Alexander (1983)

VI. CONCLUSIONS AND RECOMMENDATIONS

A literature review covering more than four decades of research and development on the decision-theoretic approach to personnel selection has produced the following major conclusions:

1. There is a difference between utility (the value obtained from the use of a selection device) and utility theory (the incorporation of value judgments in the selection strategy).

2. Personnel selection decisions have become increasingly more complex, requiring consideration of multiple attributes measured on incommensurate scales (e.g., quality, adverse impact, minority representation, and costs).

3. The political, legal, social, and philosophical issues cannot be solved by psychometricians and mathematical specialists using a purely objective technology.

4. Traditional personnel selection technologies based only on test validity are too limited to be fully effective.

5. The decision-theoretic approach is an "extension" and "augmentation" of traditional technology that is both more sophisticated and more realistic than traditional validation models. The decision-theoretic approach is more realistic because it incorporates political, social, and legal constraints into the decisionmaking process.

6. The decision-theoretic approach is a multidisciplinary effort especially well suited to handling complex decision problems requiring value judgments and cost consideratons.

7. Repeated attempts to implement the decision-theoretic approach have met with strong resistance by researchers and practitioners who wish to defend the traditional technology.

8. There is no optimum selection model. Determination of the most appropriate selection strategy for a given situation can be made only by decisionmakers analyzing tradeoffs between alternate strategies.

According to Sahal (1980), the "principal dynamic force behind technical progress is the acquisition of relevant production skills rather than advances in theoretical knowledge" (p. 201). He was saying that the decision-theoretic approach to selection needed to be operationalized. Dunnette and Borman (1979) believe that the development of a personnel selection decision support system (DSS) is entirely feasible since all the technology necessary to implement such a DSS is already available. If Dunnette and Borman are correct, the recent advancements in decision-theoretic technology could be developed into an interactive, computer-assisted, decision support system. Such a DDS would meet all suggested requirements (Cronbach, 1980; Darlington, 1976; Dunnette & Borman, 1979; Novick & Petersen, 1976), and could be implemented for use on a

microcomputer. This strategy would place the decision-theoretic approach to personnel selection in the hands of most organizations, regardless of size.

Sixteen models addressing the utility of personnel selection have been discussed. Each model has proponents and critics. The one model that seems to hold the most potential for general acceptance among personnel practioners is the Brogden-Cronbach-Gleser total utility model (Cascio, 1982; Dunnette & Borman, 1979; Hunter & Schmidt, 1982). Even though it is one of the early utility models, it has been revived, primarily because of the work of Schmidt et al. (1979) in determining a procedure for estimating SD_y. Although many of the decision-theoretic models are "toy" models using hypothetical or simulated data, the Brogden-Cronbach-Gleser total utility model can be used with actual selection problems in applied settings.

References

Ash, P., & Kroeker, L. P. Personnel selection, classification, and placement. Annual Review of Psychology, 1975, 26, 481-507

Becker, G. M. Objective measures of subjective probability and utility. Psychological Review, 1962, 69, 136-148.

Becker, G. M., DeGroot, M. H., & Marschak J. Stochastic models of choice. Behavior Science, 1963, 8, 41-55.

Becker, G. M., DeGroot, M. H., & Marschak, J. Measuring utility by a single-response sequential method. Behavior Science, 1964, 9, 226-232.

Becker, G. M., & McClintock, C. G. Value: Behavioral decision theory. Annual Review of Psychology, 1967, 18, 239-286.

Ben-Shakhar, G., & Beller, M. An application of a decision-theoretic model to a quota-free selection problem. Journal of Applied Psychology, 1983, 68, 137-146.

Berhold, M. H. The use of distribution functions to represent utility functions. Management Science, 1973, 19, 825-829.

Biesheuvel, S. Personnel selection. Annual Review of Psychology, 1965, 16, 295-324.

Bobko, P., Karren, R., & Parkington, J. J. Estimation of standard deviations in utility analysis: An empirical test. Journal of Applied Psychology, 1983, 68, 170-176

Boudreau, J. W. Economic considerations in estimating the utility of human resource productivity improvement programs. Personnel Psychology, 1983, 36, 551-576. (a)

Boudreau, J. W. Effects of employee flows on utility analysis of human resource productivity improvement programs. Journal of Applied Psychology, 1983, 68, 396-406. (b)

Brabb, G. J., & Livingston, E. J. A decision analysis approach to business statistics. Decision Sciences, 1976, 7, 538-546.

Bray, D. W., & Moses, J. L. Personnel selection. Annual Review of Psychology, 1972, 23, 545-576

Brogden, H. E. On the interpretation of the correlation coefficient as a measure of predictive efficiency. Journal of Educational Psychology, 1946, 37, 65-76.

Brogden, H. E. When testing pays off. Personnel Psychology, 1949, 2, 171-183.

Brogden, H. E., & Taylor, E. K. The dollar criterion - applying the cost accounting concept to criterion construction. Personnel Psychology, 1950, 29, 133-154

Buchwald, A. M. Values and the use of tests. Journal of Consulting Psychology, 1965, 29, 49-54.

Cascio, W. F. Costing human resources: The financial impact of behavior in organizations. Boston: Kent Publishing, 1982.

Cascio, W. F., & Silbey, V. Utility of the assessment center as a selection device. Journal of Applied Psychology, 1979, 64, 107-118.

Cleary, T. A. Test bias: Prediction of grades of Negro and White students in integrated colleges. Journal of Educational Measurement, 1968, 5, 115-124.

Cole, N. S. Bias in selection. Journal of Educational Measurement, 1973, 10, 237-255.

Coombs, C. H., & Komorita, S. S. Measuring utility of money through decisions. American Journal of Psychology, 1958, 71, 383-389.

Cronbach, L. J. Equity in selection - where psychometrics and political philosophy meet. Journal of Educational Measurement, 1976, 13, 31-41.

Cronbach, L. J. Selection theory for a political world. Public Personnel Management, 1980, 9, 37-50

Cronbach, L. J., & Gleser, G. C. Psychological tests and personnel decisions. Urbana: University of Illinois Press, 1957.

Cronbach, L. J., & Schaeffer, G. A. Extensions of personnel selection theory to aspects of minority hiring (Project Report 81-A2). San Jose, CA: Center for Educational Research at Stanford, Institute for Research on Educational Finance and Governance, February 1981.

Cronbach, L. J., Yalow, E., & Schaeffer, G. A mathematical structure for analyzing fairness in selection. Personnel Psychology, 1980, 33, 693-704.

Darlington, R. B. Another look at "Cultural Fairness." Journal of Educational Measurement, 1971, 8, 71-82.

Darlington, R. B. A defense of "rational" personnel selection, and two new methods. Journal of Educational Measurement, 1976, 13, 43-52.

Darlington, R. B., & Stauffer, G. F. Use and evaluation of discrete test information in decisionmaking. Journal of Applied Psychology, 1966, 50, 125-129.

DeGroot, M. H. Some comments on the experimental nature of utility. Behavior Science, 1963, 8, 146-149.

Duncan, O, T., Ohlin, L. E., Reiss, A. J., Jr., & Stanton, H. R. Formal devices for making selection decisions. American Journal of Sociology, 1953, 58, 573-584.

Dunnette, M. D. A modified model for test validation and selection research. Journal of Applied Psychology, 1979, 30, 477-525.

Edwards, W. The theory of decisionmaking. Psychological Bulletin, 1954, 61, 380-417.

Edwards, W. Behavioral decision theory. Annual Review of Psychology, 1961, 12, 473-498.

Edwards, W. Subjective probabilities inferred from decisions. Psychological Review, 1962, 69, 109-135.

Edwards, W., Lindman, H., & Savage, L. J. Bayesian statistical inference for psychological research. Psychological Review, 1963, 70, 193-242.

Edwards, W., & Slovic, P. Seeking information to reduce the risk of decisions. American Journal of Psychology, 1965, 78, 188-197.

Eilon, S. What is a decision? Management Science, 1968, 14, 335-378.

Einhorn, H. J., & Bass, A. R. Methodology considerations relevant to discrimination in employment testing. Psychological Bulletin, 1971, 75, 261-269.

Fishburn, R. C. Utility theory. Management Science, 1968, 14, 335-378.

Galanter, E. The direct measurement of utility and subjective probability. American Journal of Psychology, 1962, 75, 208-220.

Gettys, C. F., & Willke, T. A. The application of Bayes's Theorem when true data state is uncertain. Organizational Behavior and Human Performance, 1969, 4, 125-141.

Girshick, M. A. An elementary survey of statistical decision theory. Review of Educational research, 1954, 24, 448-466.

Goodman, L. A. The use and validity of a prediction instrument, II: The validation of prediction. American Journal of Sociology, 1953, 58, 510-512.

Grant, D. A. Testing the null hypothesis and the strategy and tactics of investigating theoretical models. Psychological Review, 1962, 69, 54-61.

Gross, A. L. Prediction in future sample studies in terms of gains from selections. Psychometrika, 1973, 38, 151-172.

Gross, A. L., & Su, W. Defining a "fair" or "unbiased" selection model: A question of utilities. Journal of Applied Psychology, 1975, 60, 345-351.

Guion, R. M. Personnel selection. Annual Review of Psychology, 1967, 18, 191-216.

Guttman, I., & Raju, N. S. A minimum loss function as determiner of optimal cutting scores. Personnel Psychology, 1965, 18, 179-185.

Hammond, J. S. Better decisions with preference theory. Harvard Business Review, 1967, 45, 123-141.

Hunter, J. E. The economic benefits of personnel selection using ability tests: A state of the art review including a detailed analysis of the dollar benefit of U.S. Employment Service placements and a critique of the low cutoff method of test use. Unpublished manuscript, Department of Psychology, Michigan State University, January 14, 1981.

Hunter, J. E., & Hunter, R. F. The validity and utility of alternate predictors of job performance. Unpublished manuscript, Department of Psychology, Michigan State University, June 21, 1982.

Hunter, J. E., & Schmidt, F. L. Fitting people to jobs: The impact of personnel selection on national productivity. In M. D. Dunnette & E. A. Fleishman (Eds.), Human performance and productivity (Vol 1: Human capability assessment). Hillsdale, NJ: Lawrence Erlbaum Associates, 1982.

Hunter, J. E., Schmidt, F. L., & Rauschenberger, J. M. Fairness of psychological tests: Implications of four definitions for selection utility and minority hiring. Journal of Applied Psychology, 1977, 62, 245-260.

Irwin, F. W., & Smith, W. A. S. Value, cost, and information as determiners of decision. Journal of Experimental Psychology, 1957, 54, 229-232.

Ives, B. D. Decision theory and the practicing manager. Business Horizons, 1973, 16, 38-40.

Kao, R. C., & Rowan, T. C. A model for personnel recruiting and selection. Management Science, 1958, 13, 192-203.

Katona, G. Psychological analysis of business decisions and expectations. American Economic Review, 1946, 36, 44-62.

Katona, G. Contributions of psychological data to economic analysis. Journal of the American Statistical Association, 1947, 42, 449-459.

Keen, G. W. Computer-based decision aids: The evaluation problem. Sloan Management Review, 1975, 16, 17-29.

Keeney, R. L. An illustrated procedure for assessing multiattributed utility functions. Sloan Management Review, 1972, 14, 37-50.

Keeney, R. L. Examining corporate policy using multiattribute utility analysis, Sloan Management Review, 1975, 17, 63-76.

Kroeck, K. G., Barrett, G. V., & Alexander, R. A. Imposed quotas and personnel selection: A computer simulation study. Journal of Applied Psychology, 1983, 68, 123-136.

Lewisohn, S. A. Psychology in economics. Political Science Quarterly, 1938, 53, 233-238.

Linn, R. L. Fair test use in selection. Review of Educational Psychology, 1973, 43, 139-161.

Linn, R. L. In search of fair selection procedures. Journal of Educational Measurement, 1976, 13, 53-58.

Magee, J. F. Decision trees for decisionmaking. Harvard Business Review, 1964, 42, 126-138.

Mahoney, T. A., & England, G. W. Efficiency and accuracy of employee selection decision rules. Personnel Psychology, 1965, 18, 361-377.

Marks, B. A. Decision under uncertainty: A poet's view. Business Horizons, 1971, 14. 57-61.

Meehl, P. E., & Rosen, A. Antecedent probability and the efficiency of psychometric signs, patterns, or cutting scores. Psychological Bulletin, 1955, 52, 194-216.

Naylor, J. C., & Shine, L. C. A table for determining the increase in mean criterion score obtained by using a selection device. Journal of Industrial Psychology, 1965, 3, 33-42.

Neyman, J., & Pearson, E. S. The testing of statistical hypotheses in relation to probability a priori. Proceedings of the Cambridge Philosophical Society, 1933, 29, 492-510.

Novick, M. R. High school attainment: An example of a computer-assisted Bayesian approach to data analysis. International Statistical Review, 1973, 41, 264-271.

Novick, M. R. Novick's discussion for CAT '79. Unpublished Manuscript, August 1978.

Novick, M. R., & Ellis, D. D., Jr. Equal opportunity in education and employment selection. American Psychologist, 1977, 32, 306-320.

Novick, M. R., & Lindley, D. V. The use of more realistic functions in educational applications. Journal of Educational Measurement, 1978, 15, 181-191.

Novick, M. R., & Petersen, N. S. Towards equalizing educational and employment opportunity. Journal of Educational Measurement, 1976, 13, 77-88.

Owens, W. A., & Jewell, D. O. Personnel selection. Annual Review of Psychology , 1969, 20, 419-446.

Petersen, N. S. An expected utility model for "optimum" selection. Journal of Educational Statistics, 1976, 1, 333-358.

Petersen, N. S., & Novick, M. R. An evaluation of some models for culture-fair selection. Journal of Educational Measurement, 1976, 13, 3-30.

Raiffa, H., & Schlaifer, R. Applied statistical decision theory. Boston: Harvard University, 1961.

Rimm, D. Cost efficiency and test prediction. Journal of Consulting Psychology, 1963. 27, 89-91.

Roberts, H. V. Probabilistic prediction. American Statistical Association Journal, 1965, 60, 50-62.

Sahal, D. Research, development, and technological innovation. Lexington, MA: Lexington Books, H. C. Heath & Co., 1980.

Sands, W. A. Method for evaluating alternative recruiting selection strategies: The CAPER model. Journal of Applied Psychology, 1973, 57, 222-227.

Savage, L. J. The foundations of statistics. New York: John Wiley & Sons, 1954.

Sawyer, R. L., Cole, N. S., & Cole, J. W. L. Utilities and the issue of fairness in decision theoretic model for selection. Journal of Educational Measurement, 1976, 59-76.

Schaeffer, G. A., & Cronbach, L. J. Tables relating quality of persons hired to selection ratio for minority applicants (Project Report 80-A20). San Jose, CA: Center for Educational Research at Stanford, Institute for Research on Educational Finance and Governance, December 1980.

Schmidt, F. L., & Hoffman, B. Empirical comparison of three methods of assessing utility of a selection device. Journal of Industrial and Organizational Psychology, 1973, 1, 13.

Schmidt, F. L., & Hunter, J. E. The future of criterion-related validity. Personnel Psychology, 1980, 33, 41-60.

Schmidt, F. L., & Hunter, J. E. Individual differences in productivity: An empirical test of estimates derived from studies of selection procedure utility. Journal of Applied Psychology, 1983, 68, 407-414.

Schmidt, F. L., Hunter, J. E., McKenzie, R. C., & Muldrow, T. W. Impact of valid selection procedures on work-force productivity. Journal of Applied Psychology, 1979, 64, 609-626.

Schmidt, F. L., Hunter, J. E., & Pearlman, K. Assessing the economic impact of personnel programs on work force productivity. Personnel Psychology, 1982, 333-345.

Shell, R. L., & Stelzer, D. F. Systems analysis: Aid to decisionmaking. Business Horizons, 1971, 14, 67-72.

Smith, R. D., & Greenlaw, P. S. Simulation of a psychological process in personnel selection. Management Science, 1967, 13, B-409-419.

Stone, C. H., & Kendell, W. E. Effective personnel selection procedures. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1956.

Swalm, R. O. Utility theory - insights into risk taking. Harvard Business Review, 1966 44 , 123-136.

Taylor, H. C., & Russell, J. T. The relationship of validity coefficients to the practical effectiveness of tests in selection: Discussion and tables. Journal of Applied Psychology, 1939, 13, 565-578.

Thorndike, R. L. Concepts of culture-fairness. Journal of Educational Measurement, 1971, 8, 63-70.

von Haller Gilmer, B. Industrial psychology. Annual Review of Psych, 1960, 11, 323-350.

von Neumann, J., & Morgenstern, O. Theory of games and economic behavior. Princeton: Princeton University Press, 1947.

Wald, A. Statistical decision functions. New York: Wiley, 1950.

Weisskopf, W. A. Psychological aspects of economic thought. Journal of Political Economics, 1949, 57, 304-314.

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